Cooling Load Check Figures

Classifications	Occupancy Sq Ft/Person			Lights and Other Electrical Watts/Sq Ft			Refrigeration Sq Ft/Ton‡			Supply Air Rate CFM/Sq Ft								
										East-South-West			North			Internal		
	Lo	Av	Hi	Lo	Av	Hi	Lo	Av	Hi	Lo	Av	Hi	Lo	Av	Hi	Lo	Av	Hi
Apartment, High Rise	325	175	100	0.7	0.9	1.1	450	400	350	0.8	1.2	1.7	0.5	0.8	1.3	–	–	–
Auditoriums, Churches, Theaters	15	11	6	0.5	0.7	0.9	400	250	90	–	–	–	–	–	–	1.0	2.0	3.0
Educational Facilities	30	25	20	0.75	1.0	1.1	240	185	150	1.0	1.6	2.2	0.9	1.3	2.0	0.8	1.2	1.9
Schools, Colleges, Universities																		
Factories Assembly Areas	50	35	23	2.5†	4.0†	5.5†	240	150	90	–	–	–	–	–	–	2.0	3.6	5.5
Light Manufacturing	200	150	100	7.5†	9†	11†	200	150	100	–	–	–	–	–	–	1.6	2.5	3.8
Heavy Manufacturing*	200	250	300	12†	25†	30†	100	80	60	–	–	–	–	–	–	2.5	4.0	6.5
Hospitals Patient Rooms	70	50	25	0.5	0.75	1.0	275	220	165	1.0	1.5	2.0	0.8	1.2	1.4	0.7	1.0	1.3
Public Areas	100	80	50	0.5	0.75	1.0	175	140	110	1.0	1.25	1.45	1.0	1.1	1.2	0.95	1.0	1.1
Hotels, Motels, Dormitories	200	150	100	0.5	0.75	1.0	350	300	220	1.0	1.40	1.5	0.9	1.2	1.4	–	–	–
Libraries and Museums	80	60	40	0.5	0.75	1.0	340	280	200	1.0	1.6	2.1	0.9	1.1	1.3	0.9	1.0	1.1
Office Buildings (General)	130	110	80	2†	2.5†	4†	360	280	190	1.0	1.6	2.2	0.9	1.3	2.0	0.8	1.0	1.2
Private Offices	150	125	100	0.5	0.75	1.0	–	–	–	1.2	1.8	2.4	1.1	1.5	1.8	0.8	1.2	1.4
Stenographic Department	100	85	70	1.0	1.25	1.5	–	–	–	–	–	–	–	–	–	0.9	1.3	2.0
Residential Large	600	400	200	0.5	1.0	1.5	600	500	380	0.8	1.2	1.6	0.5	0.8	1.3	–	–	–
Medium	600	360	200	0.5	1.0	1.5	700	550	400	0.7	1.1	1.4	0.5	0.7	1.2	-	-	-
Restaurants Large	17	15	13	0.5	1.0	1.5	135	100	80	1.8	2.4	3.7	1.2	1.6	2.1	0.9	1.1	1.4
Medium							150	120	100	1.5	2.0	3.0	1.1	1.4	1.8	0.9	1.0	1.3
Shopping Centers, Department Stores and Specialty Shops																		
Beauty and Barber Shops	45	40	25	3.0†	5.0†	9.0†	240	160	105	1.5	2.6	4.2	1.1	1.7	2.6	0.9	1.3	2.0
Malls	100	75	50	1.0	1.5	2.0	365	230	160	–	–	–	–	–	–	1.1	1.8	2.5
Refrigeration for Central Heating and Cooling Plant																		
Urban Districts							475	380	285									
College Campuses							400	320	240									
Commercial Centers							330	265	200									
Residential Centers							625	500	375									

Refrigeration and air quantities for applications listed in this table of cooling load check figures are based on all-air system and normal outdoor air quantities for ventilation except as noted.

Notes: †Refrigeration loads are for entire application

*Air quantities for heavy manufacturing areas are based on supplementary means to remove excessive heat.

Rates of Heat Gain from Occupants of Conditioned Spaces

Degree of Activity		Total Heat, Btu/h		Sensible Heat, Btu/h	Latent Heat, Btu/h	% Sensible Heat that is Radiant[b]	
		Adult Male	Adjusted, M/F[a]			Low V	High V
Seated at theater	Theater, matinee	390	330	225	105		
Seated at theater, night	Theater, night	390	350	245	105	60	27
Seated, very light work	Offices, hotels, apartments	450	400	245	155		
Moderately active office work	Offices, hotels, apartments	475	450	250	200		
Standing, light work; walking	Department store; retail store	550	450	250	200	58	38
Walking, standing	Drug store, bank	550	500	250	250		
Sedentary work	Restaurant[c]	490	550	275	275		
Light bench work	Factory	800	750	275	475		
Moderate dancing	Dance hall	900	850	305	545	49	35
Walking 3 mph; light machine work	Factory	1000	1000	375	625		
Bowling[d]	Bowling alley	1500	1450	580	870		
Heavy work	Factory	1500	1450	580	870	54	19
Heavy machine work; lifting	Factory	1600	1600	635	965		
Athletics	Gymnasium	2000	1800	710	1090		

Notes:

1. Tabulated values are based on 75°F room dry-bulb temperature. For 80°F room dry bulb, the total heat remains the same, but the sensible heat values should be decreased by approximately 20%, and the latent heat values increased accordingly.
2. Also refer to Table 4, Chapter 8, for additional rates of metabolic heat generation.
3. All values are rounded to nearest 5 Btu/h.

[a] Adjusted heat gain is based on normal percentage of men, women, and children for the application listed, with the postulate that the gain from an adult female is 85% of that for an adult male, and that the gain from a child is 75% of that for an adult male.

[b] Values approximated from data in Table 6, Chapter 8, where is air velocity with limits shown in that table.

[c] Adjusted heat gain includes 60 Btu/h for food per individual (30 Btu/h sensible and 30 Btu/h latent).

[d] Figure one person per alley actually bowling, and all others as sitting (400 Btu/h) or standing or walking slowly (550 Btu/h).

Heat Gain from Lighting

The energy absorbed by the structure and contents contributes to space cooling load only after a time lag, some still reradiating after the heat sources have been switched off. This may make load lower than instantaneous heat gain, thus affecting the peak load.

Instantaneous rate of heat gain from lights, q_{el} Btu/h:

$$q_{el} = 3.41 \text{ W } F_{ue} F_{sa}$$

where

W = total lights wattage installed
F_{ue} = lighting use factor (proportion in use)
F_{sa} = lighting special allowance factor

The **total light wattage** is obtained from the ratings of all lamps installed, both for general illumination and for display use. Ballasts are not included, but are addressed by a separate factor. Wattages of magnetic ballasts are significant; the energy consumption of high-efficiency electronic ballasts might be insignificant compared to that of the lamps.

The **lighting use factor** is the ratio of wattage in use, for the conditions under which the load estimate is being made, to total installed wattage. For commercial applications such as stores, the use factor is generally 1.0.

The **special allowance factor** is the ratio of the lighting fixtures' power consumption, including lamps and ballast, to the nominal power consumption of the lamps. For incandescent lights, this factor is 1. For fluorescent lights, it accounts for power consumed by the ballast as well as the ballast's effect on lamp power consumption. The special allowance factor can be less than 1 for electronic ballasts that lower electricity consumption below the lamp's rated power consumption. Use manufacturers' values for system (lamps + ballast) power, when available.

For high-intensity-discharge lamps (e.g. metal halide, mercury vapor, high- and low-pressure sodium vapor lamps), the actual lighting system power consumption should be available from the manufacturer of the fixture or ballast. Ballasts available for metal halide and high pressure sodium vapor lamps may have special allowance factors from about 1.3 (for low-wattage lamps) down to 1.1 (for high-wattage lamps).

An alternative procedure is to estimate the lighting heat gain on a per square foot basis. Such an approach may be required when final lighting plans are not available. Table 2 shows the maximum lighting power density (LPD) (lighting heat gain per square foot) allowed by ASHRAE *Standard* 90.1-2007 for a range of space types.

Lighting Power Densities Using Space-by-Space Method

Common Space Types*	LPD, W/ft²	Building-Specific Space Types	LPD, W/ft²
Office—enclosed	1.1	Gymnasium/exercise center	
Office—open plan	1.1	Playing Area	1.4
Conference/meeting/multipurpose	1.3	Exercise Area	0.9
Classroom/lecture/training	1.4	Courthouse/police station/penitentiary	
For penitentiary	1.3	Courtroom	1.9
Lobby	1.3	Confinement cells	0.9
For hotel	1.1	Judges' chambers	1.3
For performing arts theater	3.3	Fire Stations	
For motion picture theater	1.1	Engine room	0.8
Audience/seating Area	0.9	Sleeping quarters	0.3
For gymnasium	0.4	Post office—sorting area	1.2
For exercise center	0.3	Convention center—exhibit space	1.3
For convention center	0.7	Library	
For penitentiary	0.7	Card file and cataloging	1.1
For religious buildings	1.7	Stacks	1.7
For sports arena	0.4	Reading area	1.2
For performing arts theater	2.6	Hospital	
For motion picture theater	1.2	Emergency	2.7
For transportation	0.5	Recovery	0.8

Lighting Power Densities Using Space-by-Space Method (Continued)

Atrium—first three floors	0.6
Atrium—each additional floor	0.2
Lounge/recreation	1.2
For hospital	0.8
Dining Area	0.9
For penitentiary	1.3
For hotel	1.3
For motel	1.2
For bar lounge/leisure dining	1.4
For family dining	2.1
Food preparation	1.2
Laboratory	1.4
Restrooms	0.9
Dressing/locker/fitting room	0.6
Corridor/transition	0.5
For hospital	1.0
For manufacturing facility	0.5
Stairs—active	0.6
Active storage	0.8
For hospital	0.9
Inactive storage	0.3
For museum	0.8
Electrical/mechanical	1.5
Workshop	1.9
Sales area [for accent lighting, see Section 9.6.2(B) of ASHRAE *Standard* 90.1]	1.7
Nurses' station	1.0
Exam/treatment	1.5
Pharmacy	1.2
Patient room	0.7
Operating room	2.2
Nursery	0.6
Medical supply	1.4
Physical therapy	0.9
Radiology	0.4
Laundry—washing	0.6
Automotive—service/repair	0.7
Manufacturing	
Low bay (<25 ft floor to ceiling height)	1.2
High bay (≥25 ft7.6 m floor to ceiling height)	1.7
Detailed manufacturing	2.1
Equipment room	1.2
Control room	0.5
Hotel/motel guest rooms	1.1
Dormitory—living quarters	1.1
Museum	
General exhibition	1.0
Restoration	1.7
Bank/office—banking activity area	1.5
Religious buildings	
Worship pulpit, choir	2.4
Fellowship hall	0.9
Retail	
Sales area for accent lighting, see Section 9.6.3(C) of ASHRAE *Standard* 90.1]	1.7
Mall concourse	1.7
Sports arena	
Ring sports area	2.7
Court sports area	2.3
Indoor playing field area	1.4
Warehouse	
Fine material storage	1.4
Medium/bulky material storage	0.9
Parking garage—garage area	0.2
Transportation	
Airport—concourse	0.6
Air/train/bus—baggage area	1.0
Terminal—ticket counter	1.5

Source: ASHRAE *Standard* 90.1-2007.

*In cases where both a common space type and a building-specific type are listed, the building-specific space type applies.

Heat Gain from Motors and their Loads

Instantaneous rate of heat gain from equipment operated by electric motors within a conditioned space.

$$q_{em} = 2545\ (P/E_m)\ F_{um}\ F_{LM}$$

where

q_{em} = heat equivalent of equipment operation
P = motor power rating, hp
E_m = motor efficiency, decimal fraction < 1.0
F_{um} = motor use factor 1.0 or <1.0 (proportion operating)
F_{LM} = motor load factor 1.0 or <1.0

When motor is outside the conditioned space, but load is inside,

$$q_{em} = 2545\ P\ F_{um}\ F_{LM}$$

When motor is inside the conditioned space, but load is outside,

$$q_{em} = 2545P\left(\frac{1.0 - E_m}{E_m}\right) F_{um}\ F_{em}$$

Minimum Nominal Efficiency for General Purpose Design A and Design B Motors

	Minimum Nominal Full-Load Efficiency, %					
	Open Motors			Enclosed Motors		
Number of Poles ⇒	**2**	**4**	**6**	**2**	**4**	**6**
Synchronous Speed (RPM) ⇒	**3600**	**1800**	**1200**	**3600**	**1800**	**1200**
Motor Horsepower						
1	—	82.5	80.0	75.5	82.5	80.0
1.5	82.5	84.0	84.0	82.5	84.0	85.5
2	84.0	84.0	85.5	84.0	84.0	86.5
3	84.0	86.5	86.5	85.5	87.5	87.5
5	85.5	87.5	87.5	87.5	87.5	87.5
7.5	87.5	88.5	88.5	88.5	89.5	89.5
10	88.5	89.5	90.2	89.5	89.5	89.5
15	89.5	91.0	90.2	90.2	91.0	90.2
20	90.2	91.0	91.0	90.2	91.0	90.2
25	91.0	91.7	91.7	91.0	92.4	91.7
30	91.0	92.4	92.4	91.0	92.4	91.7
40	91.7	93.0	93.0	91.7	93.0	93.0
50	92.4	93.0	93.0	92.4	93.0	93.0
60	93.0	93.6	93.6	93.0	93.6	93.6
75	93.0	94.1	93.6	93.0	94.1	93.6
100	93.0	94.1	94.1	93.6	94.5	94.1
125	93.6	94.5	94.1	94.5	94.5	94.1
150	93.6	95.0	94.5	94.5	95.0	95.0
200	94.5	95.0	94.5	95.0	95.0	95.0

Heat output of a motor is generally proportional to motor load, within rated overload limits. Because of typically high no-load motor current, fixed losses, and other reasons, F_{LM} is generally assumed to be unity, and no adjustment should be made for underloading or overloading unless the situation is fixed and can be accurately established, and reduced-load efficiency data can be obtained from the motor manufacturer. Unless the manufacturer's technical literature indicates otherwise, motor heat gain normally should be equally divided between radiant and convective components for the subsequent cooling load calculations.

Cooking Appliances

Heat gain: $q_s = q_{input} F_U F_R$, where F_U is the usage factor and F_R is the radiation factor.

Recommended Rates of Radiant and Convective Heat Gain from Unhooded Electric Appliances During Idle (Ready-to-Cook) Conditions

Appliance	Energy Rate, Btu/h		Rate of Heat Gain, Btu/h				Usage Factor F_u	Radiation Factor F_r
	Rated	Standby	Sensible Radiant	Sensible Convective	Latent	Total		
Cabinet: hot serving (large), insulated*	6,800	1,200	400	800	0	1,200	0.18	0.33
Cabinet: hot serving (large), uninsulated	6,800	3,500	700	2,800	0	3,500	0.51	0.2
Cabinet: proofing (large)*	17,400	1,400	1,200	0	200	1,400	0.08	0.86
Cabinet: proofing (small-15 shelf)	14,300	3,900	0	900	3,000	3,900	0.27	0
Coffee brewing urn	13,000	1,200	200	300	700	1,200	0.09	0.17
Drawer warmers, 2-drawer (moist holding)*	4,100	500	0	0	200	200	0.12	0
Egg cooker	10,900	700	300	400	0	700	0.06	0.43
Espresso machine*	8,200	1,200	400	800	0	1,200	0.15	0.33
Food warmer: steam table (2-well-type)	5,100	3,500	300	600	2,600	3,500	0.69	0.09
Freezer (small)	2,700	1,100	500	600	0	1,100	0.41	0.45
Hot dog roller*	3,400	2,400	900	1,500	0	2,400	0.71	0.38
Hot plate: single burner, high speed	3,800	3,000	900	2,100	0	3,000	0.79	0.3
Hot-food case (dry holding)*	31,100	2,500	900	1,600	0	2,500	0.08	0.36
Hot-food case (moist holding)*	31,100	3,300	900	1,800	600	3,300	0.11	0.27
Microwave oven: commercial (heavy duty)	10,900	0	0	0	0	0	0	0
Oven: countertop conveyorized bake/finishing*	20,500	12,600	2,200	10,400	0	12,600	0.61	0.17
Panini*	5,800	3,200	1,200	2,000	0	3,200	0.55	0.38
Popcorn popper*	2,000	200	100	100	0	200	0.1	0.5
Rapid-cook oven (quartz-halogen)*	41,000	0	0	0	0	0	0	0
Rapid-cook oven (microwave/convection)*	24,900	4,100	1,000	3,100	0	1,000	0.16	0.24
Reach-in refrigerator*	4,800	1,200	300	900	0	1,200	0.25	0.25
Refrigerated prep table*	2,000	900	600	300	0	900	0.45	0.67
Steamer (bun)	5,100	700	600	100	0	700	0.14	0.86
Toaster: 4-slice pop up (large): cooking	6,100	3,000	200	1,400	1,000	2,600	0.49	0.07
Toaster: contact (vertical)	11,300	5,300	2,700	2,600	0	5,300	0.47	0.51
Toaster: conveyor (large)	32,800	10,300	3,000	7,300	0	10,300	0.31	0.29
Toaster: small conveyor	5,800	3,700	400	3,300	0	3,700	0.64	0.11
Waffle iron	3,100	1,200	800	400	0	1,200	0.39	0.67

Cooling Load Estimates for Various Office Load Densities

	Number	Each, W	Total, W	Diversity	Load, W
Light Load Density[a]					
Computers	6	55	330	0.67	220
Monitors	6	55	330	0.67	220
Laser printer—small desk top	1	130	130	0.33	43
Fax machine	1	15	15	0.67	10
Total Area Load					494
Recommended equipment load factor = 0.5 W/ft^2					
Medium Load Density[a]					
Computers	8	65	520	0.75	390
Monitors	8	70	560	0.75	420
Laser printer—desk	1	215	215	0.5	108
Fax machine	1	15	15	0.75	11
Total Area Load					929
Recommended equipment load factor = 1.0 W/ft^2					
Medium/Heavy Load Density[a]					
Computers	10	65	650	1	650
Monitors	10	70	700	1	700
Laser printer—small office	1	320	320	0.5	160
Facsimile machine	1	30	30	0.5	15
Total Area Load					1525
Recommended equipment load factor = 1.5 W/ft^2					
Heavy Load Density[a]					
Computers	12	75	900	1	900
Monitors	12	80	960	1	960
Laser printer-small office	1	320	320	0.5	160
Facsimile machine	1	30	30	0.5	15
Total Area Load					2035
Recommended equipment load factor = 2.0 W/ft^2					

Source: Wilkins and McGaffin (1994).